Photogrammetry II

3rd Stage

Stereoscopic Plotting Instruments & Angular Orientation

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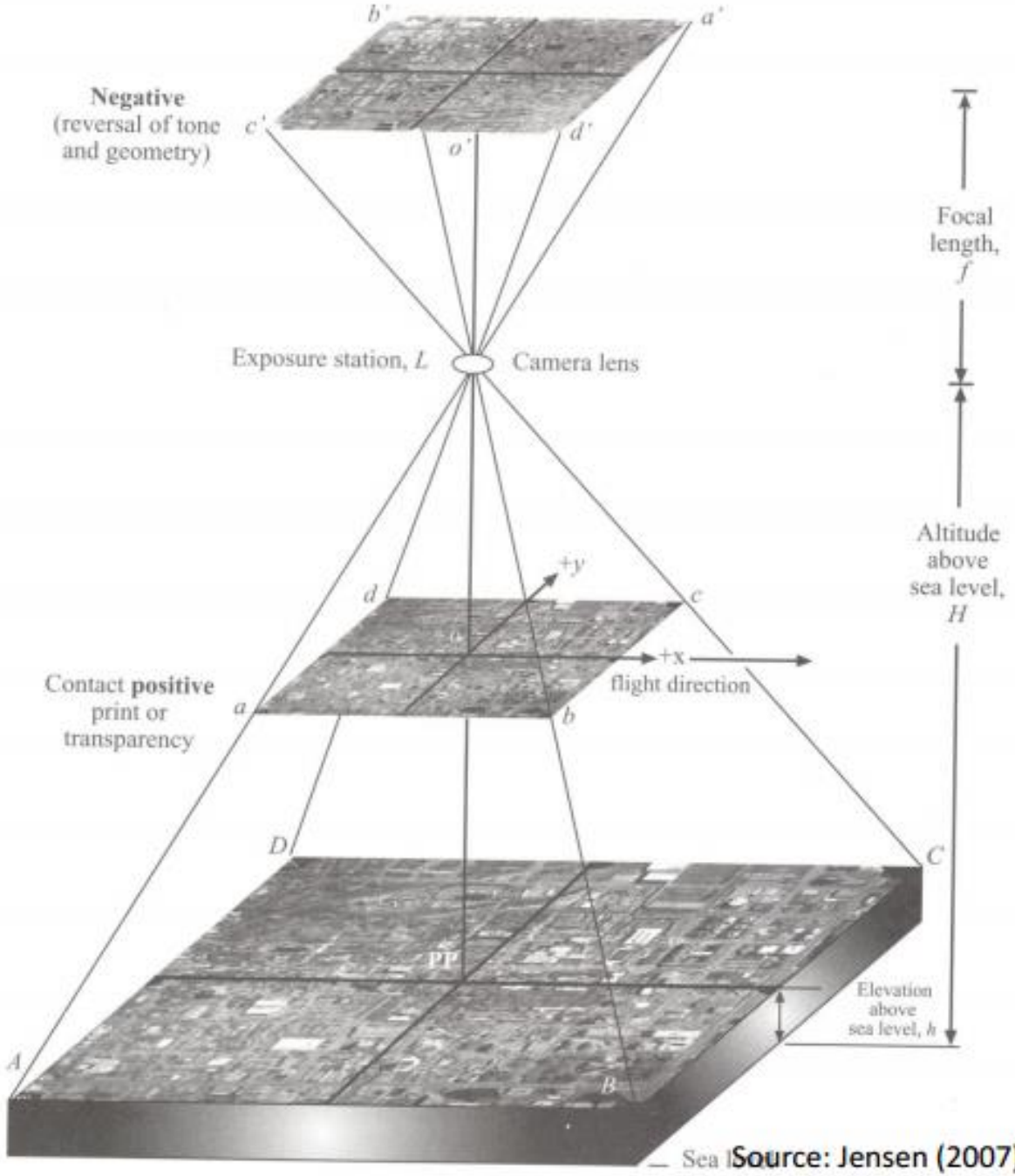
Stereoscopic plotters from previous lecture!

Soft-copy Photogrammetry

- *Soft-copy* means that a digital image is analyzed, not a hard copy image.
- The first photogrammetric soft-copy system was developed in the early 1980s, by James Case.
- Soft-copy photogrammetry includes:
  - Processing of digital imagery
  - Stereo-viewing of digital imagery
  - Deriving digital elevation/surface models (DEMs/DSMs)
  - Extracting contours
  - Producing orthophotos and ortho mosaics
  - Extracting planimetric features

Stereo aerial photos required.

• In order to be able to use photos as true spatial representations of the real-world, geometric relations need to be established between the camera's , photo's and real-world's coordinate systems.



Source: Jensen (2007)

Photogrammetric Orientations

- Interior Orientation (Inner Orientation)
- Exterior Orientation (Outer Orientation)
- Relative Orientation
- Absolute Orientation

Interior Orientation

- The purpose of inner orientation is to recreate the geometry of rays at the time of exposure
- The procedure described here is with reference to an analogue streoplotter
- Inner orientation involves:
  - Correctly centering the two photographs in the stereoplotter in order to exactly locate the principal point
  - Introduce the principal distance in the instrument

Interior Orientation

- The procedure whereby the geometric characteristics of an aerial photograph are mathematically related to the geometric characteristics (including deformities) of the camera system that took the photograph.

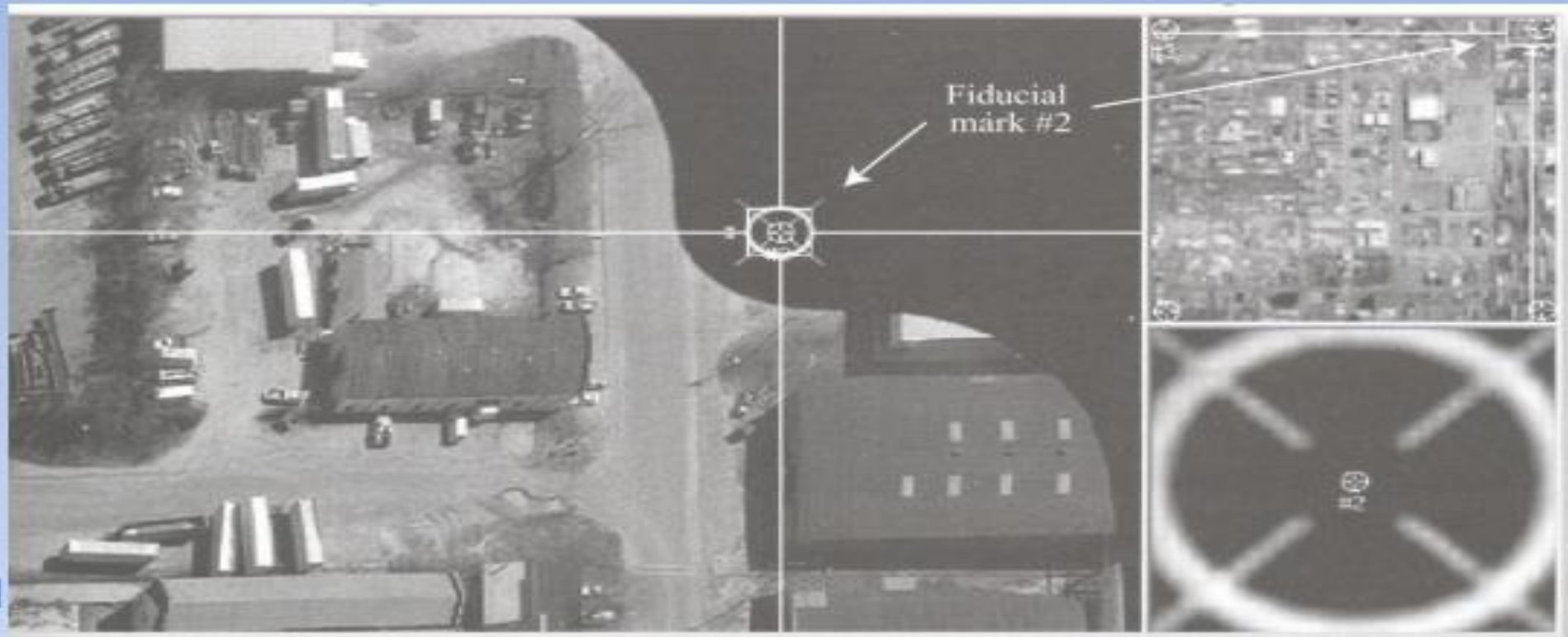
- The relationship is established between the camera internal coordinate system and the image pixel coordinate system.

- The information on the camera system is usually found in the camera calibration report, created when the camera was produced or recalibrated.

- Typical information required for interior orientation that is available in the camera calibration report includes:

  - ❑ x,y location of the principal point (e.g., x,y = 0,0)
  - ❑ x,y location of all fiducial marks (mm)
  - ❑ lens focal length (cm)
  - ❑ deformation characteristics of the lens

Interior Orientation



Sensor | Interior Orientation | Exterior Information

Fiducial Orientation:

Edit All Images...

Viewer Fiducial Locator

Auto Locate...

50 0 100

50 0 100

Apply Reset

RMSE 1.12pixels

or 56.7Emicrons

Solve

Point #	>	Color	Image X	Image Y	Film X	Film Y	Residual X	Residual Y
1			153.531	4350.531	-106.007	-105.006	-1.121	0.047
2	>		4329.591	137.691	106.001	105.996	-1.121	0.047
3			132.471	159.525	-106.002	105.996	1.121	0.047
4			4340.169	4328.510	105.996	-106.006	1.121	0.047

Exterior Orientation

- Relates image (photo) coordinates to real-world (*exterior)* map coordinates.

- Reference real-world points are called Ground Control Points (GCP) and their position is expressed in the coordinates of a chosen map coordinate system.

- All aerial photographs are somewhat tilted and this tilt has to be calculated in the model to be able to derive useful measurements from aerial photos.

- There are six elements of exterior orientation that express the spatial location and angular orientation of a tilted photograph:

  - ❑ X_L, Y_L, Z_L – the three dimensional coordinates of the aircraft (camera) at the moment of the exposure.
  - ❑ Omega, phi, and kappa (ω, ϕ, κ) – rolling, pitch, and yawning of the camera at the moment of exposure.

- All the methods developed to determine these six parameters require identification and X, Y, Z coordinates of at least 3 Ground Control Points on the photo.

- The GCP points need to form a triangle on the photo, they cannot lie in a straight line.

Exterior Orientation

• Ideally, GCPs are marked on the ground and precisely measured (e.g. with GPS), but another method of obtaining their location is by using Geographic Information System layers which share identifiable points with the aerial photo (a particular point can be located on both sources).

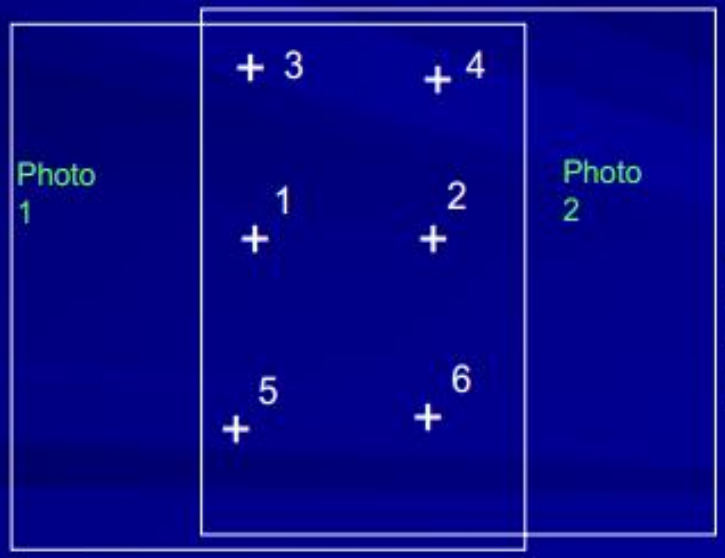
• In addition to GCP points, *pass (tie)* points – identifiable on multiple photos and with unknown real-world coordinates – can be used as well.

• Exterior orientation can also be directly derived when GPS and IMU are onboard (e.g., ADS camera system).

Source: Jensen (2007)

Relative Orientation

- The purpose of relative orientation is to re-create a stereo model of terrain in a smaller scale such that parallax is minimized
- Choose six readily discernable image points approximately in the positions shown below:

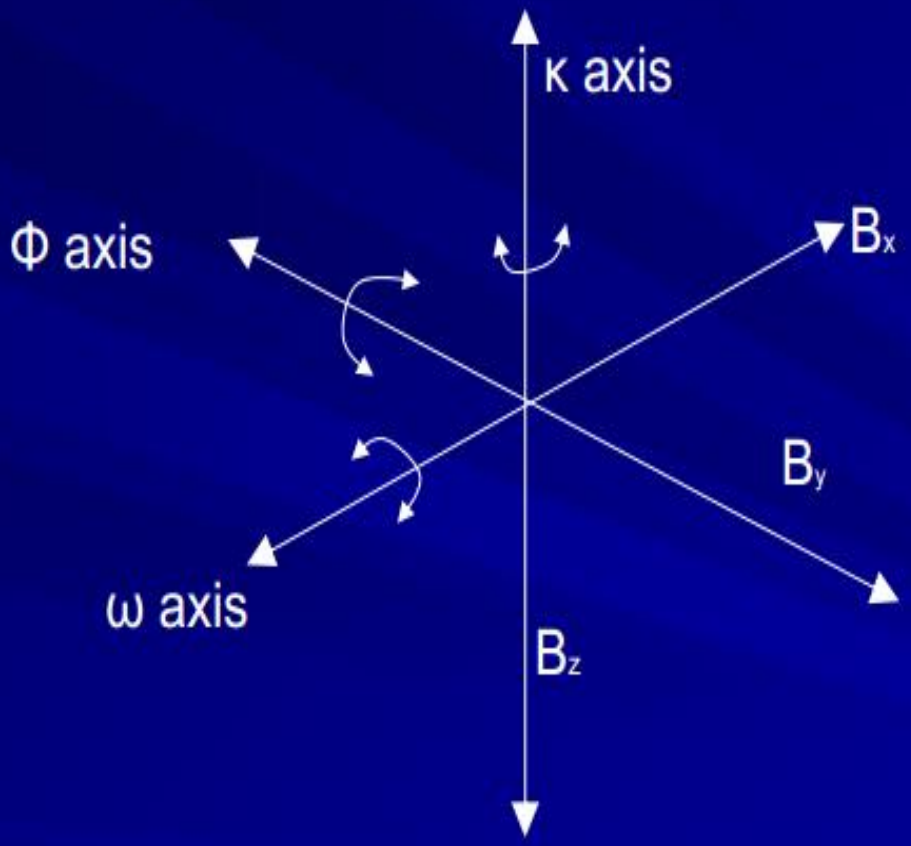


Points 1 and 2 are near the principal points of photos 1 and 2

- The image processing method of relative orientation uses image processing to compare pixel groupings on the left and right photos and determine relative points from matched sets
- The two-image selection method of relative orientation offers selection of points appearing in the overlap area of only the two open images
  - For the selection method of relative orientation, select relative points, removes parallax, and digitize each point

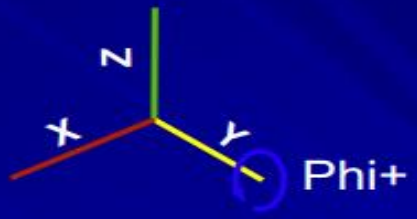
– Each projector is capable of six movements:

- Translations – x, y, z
- Rotations – ω, φ, κ

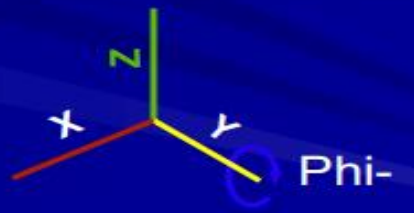


- Omega, Phi and Kappa define the orientation of the sensor when the imagery was captured.

Y is principle & Phi (+)



Y is principle & Phi (-)



- **Each projector has six motions, giving 12 motions for the stereopair**
- **Relative orientation on an analogue stereoplotter usually require fifteen to sixty minutes to be completed (depending upon the experience of the operator)**

Absolute Orientation

- The purpose is to bring the model to the desired scale and introduce the ground control information
- After inner and relative orientation the stereomodel is geometrically similar to the terrain but it must be brought to a known scale through the introduction of ground control
  - Achieved by:
    - By changing the distance between the projectors
    - Tilting the projectors together so that elevations are correctly measured

Credits

- KTH Royal Institute of Technology, Sweden
- Civil Eng. Department, Jordan University of Science and Technology